Heated Promoted Combustion-Initial Test Results

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- **The Purpose of the STD 6001 test 17 is to determine the flammability of materials in GOX at ambient temperature and at use pressure.**
- **The purpose of the new Heated Promoted combustion test is to determine the flammability of materials in GOX at use temperature and pressure.**

Objective: Present the new Heated Promoted Combustion method and show initial data and trends for three representative metals.

High-Temperature High-Pressure Promoted Ignition-Combustion Test

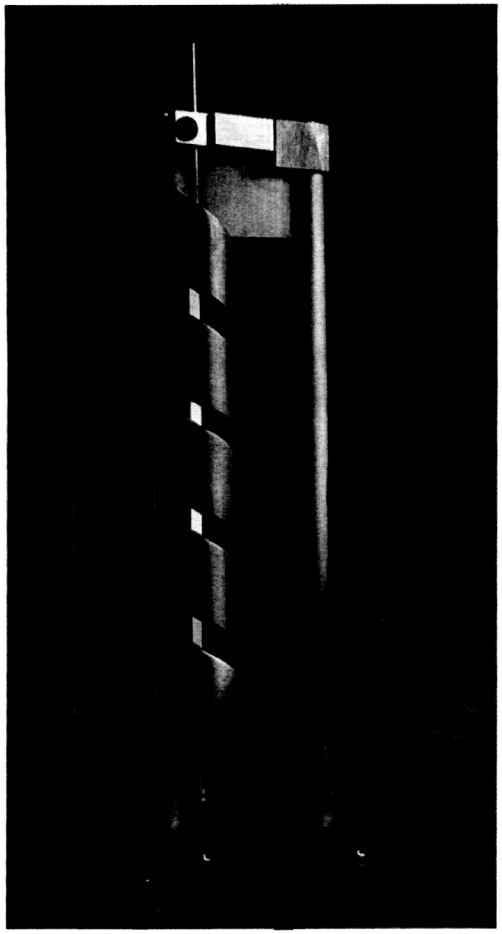
- The direct heating method at MSFC uses an **induction coil** housed inside the promoted ignition-combustion chamber, which is similar to the chamber described in ASTM 124-95.
- The MSFC improved induction heated high-pressure promoted ignition-combustion chamber can sustain a pressure of up to **10,000 psia** (6.9 MPa) in pure gaseous oxygen, and contains an induction coil capable of preheating a metal specimen to near its melting temperature [possibly in excess of **2,000° F** (1,100 C)] depending upon the test pressure.

Heated Promoted Combustion Tester

Stephen Herald, aligning one of six cameras in the chamber view port.

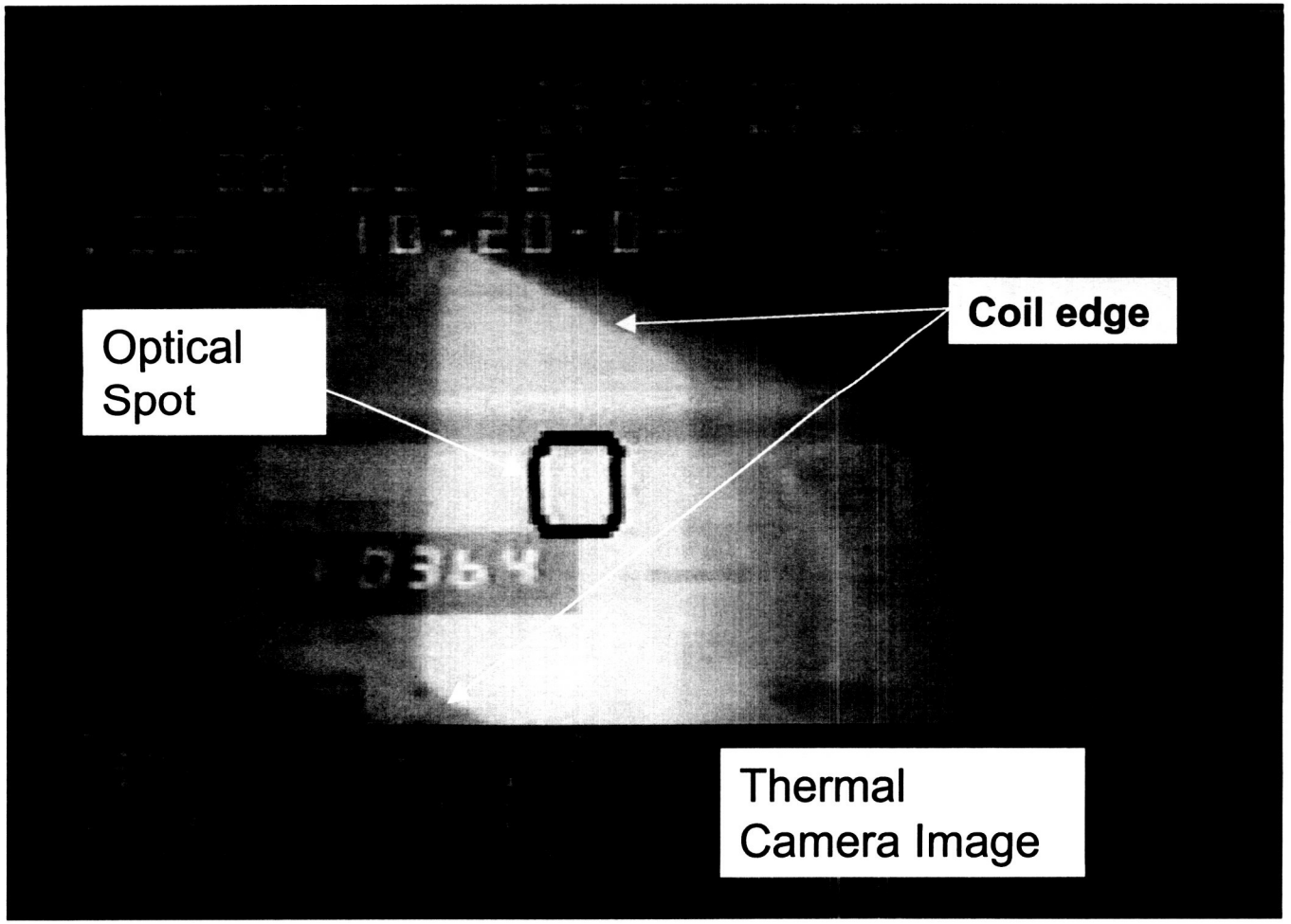
- Six site ports were arranged in a helical pattern to allow the observation of the combustion event for the entire length of the sample
- These site ports, due to the higher pressures involved in the test, are constructed out of 1.3-inch thick sapphire.
- Thermal imaging camera used for temperature measurement

Improved Induction-Coil Design

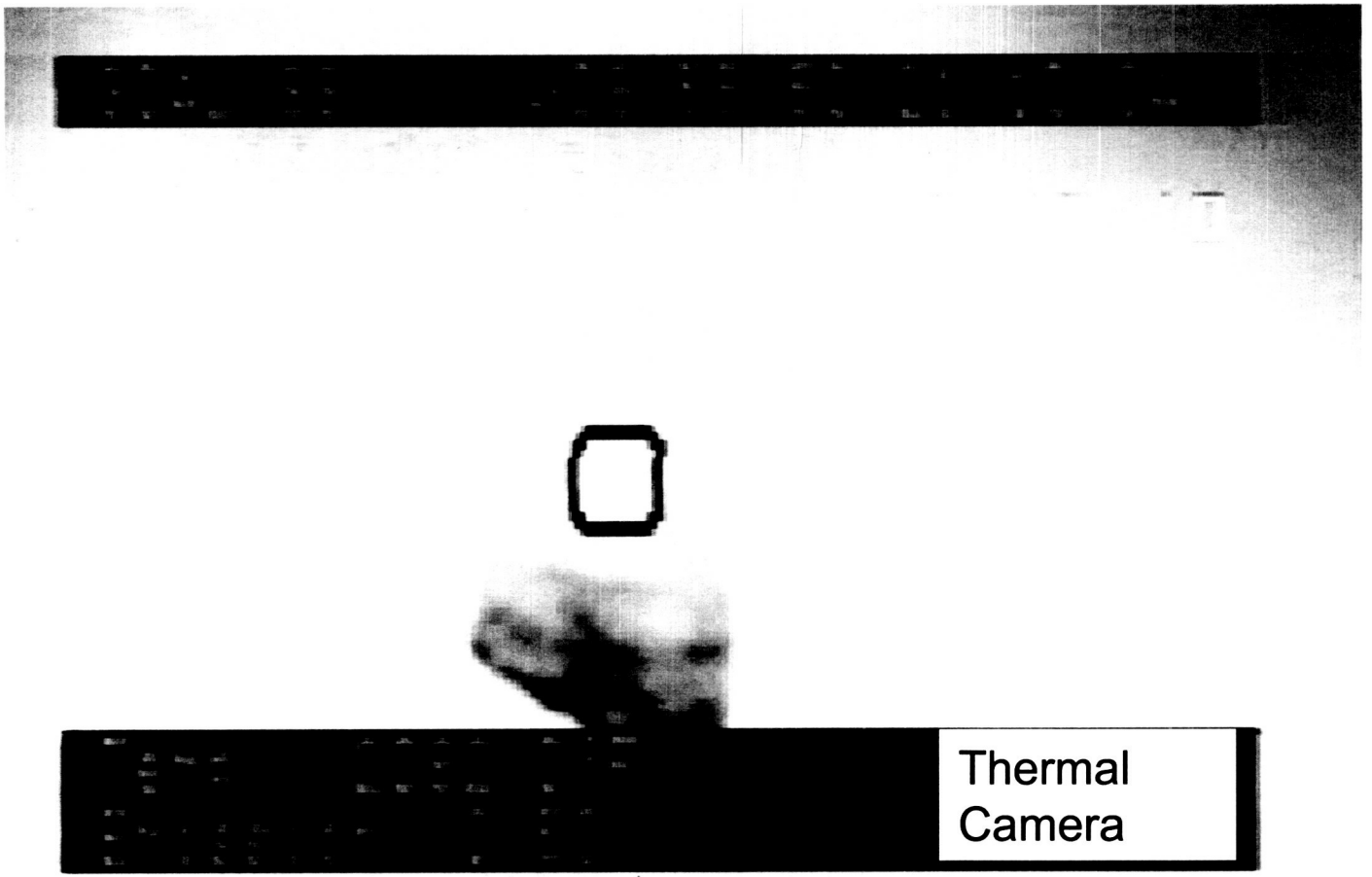


- An induction coil capable of preheating a metal specimen to near its melting temperature [possibly in excess of 2,000° F (1,100 C)] depending upon the test pressure.
- Viewing through spiral openings

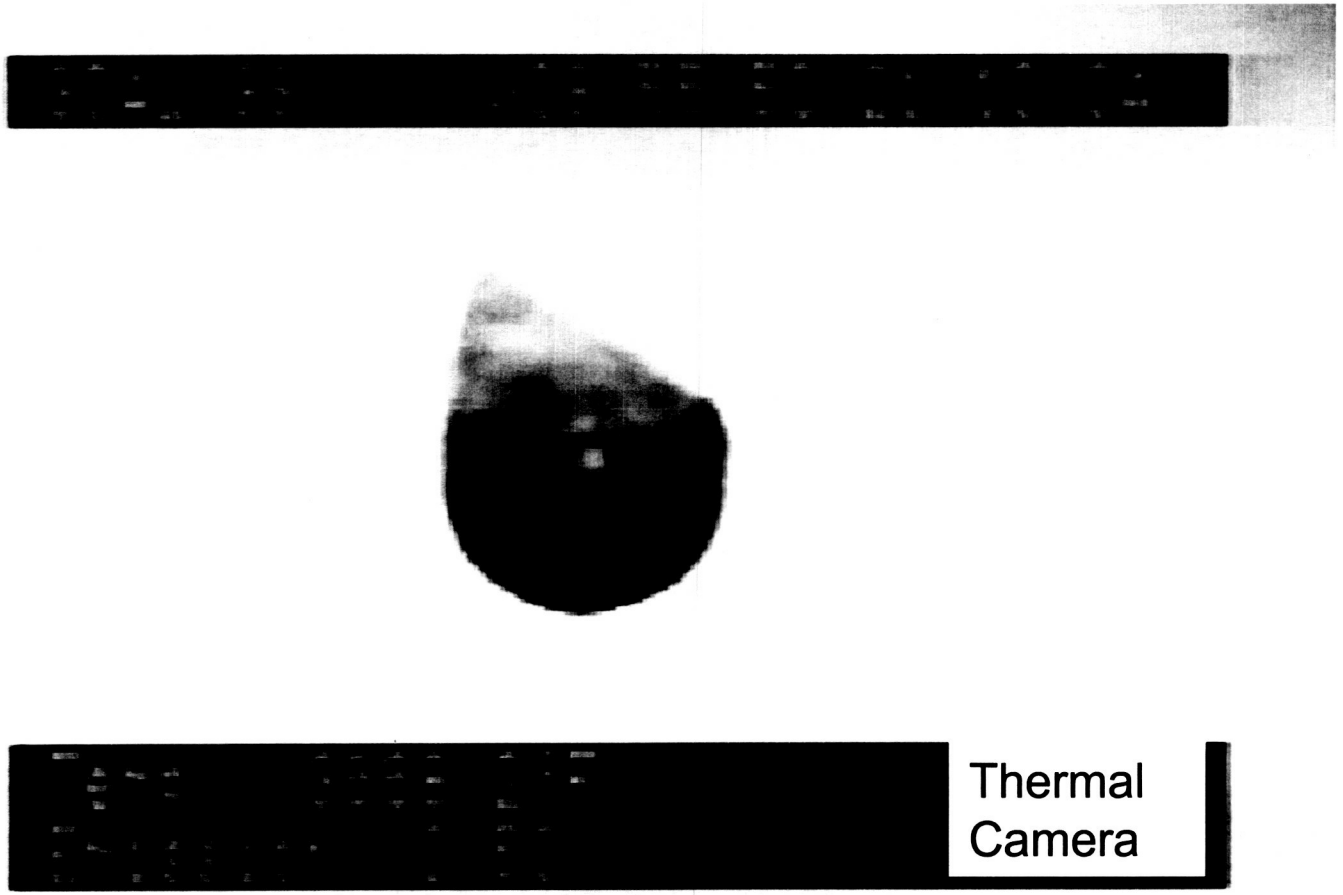
Induction-Heated Rod (1689 °F)



Burning Tip Emerging (2292 °F)



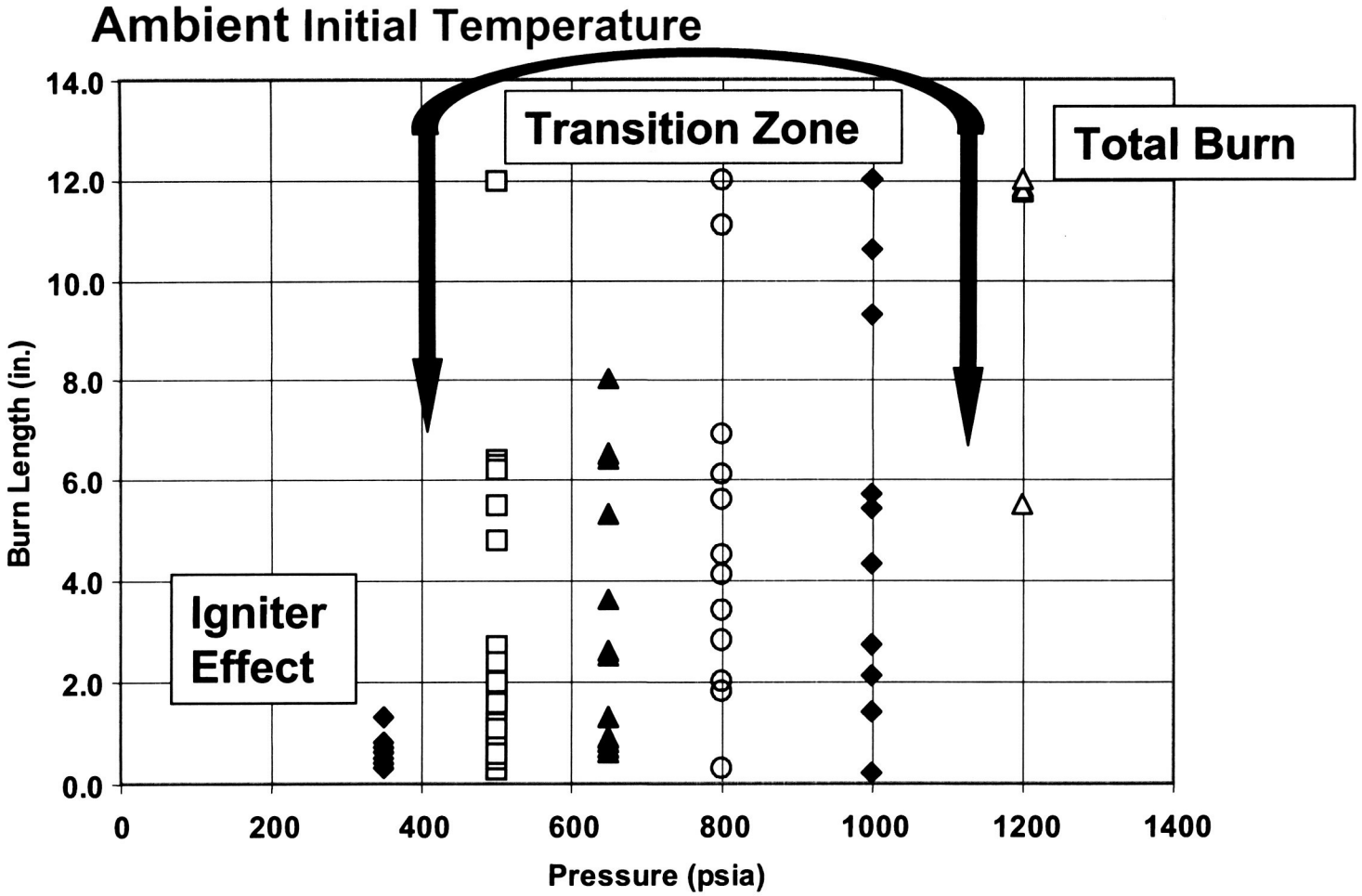
Droplet End Centered (3668 °F)



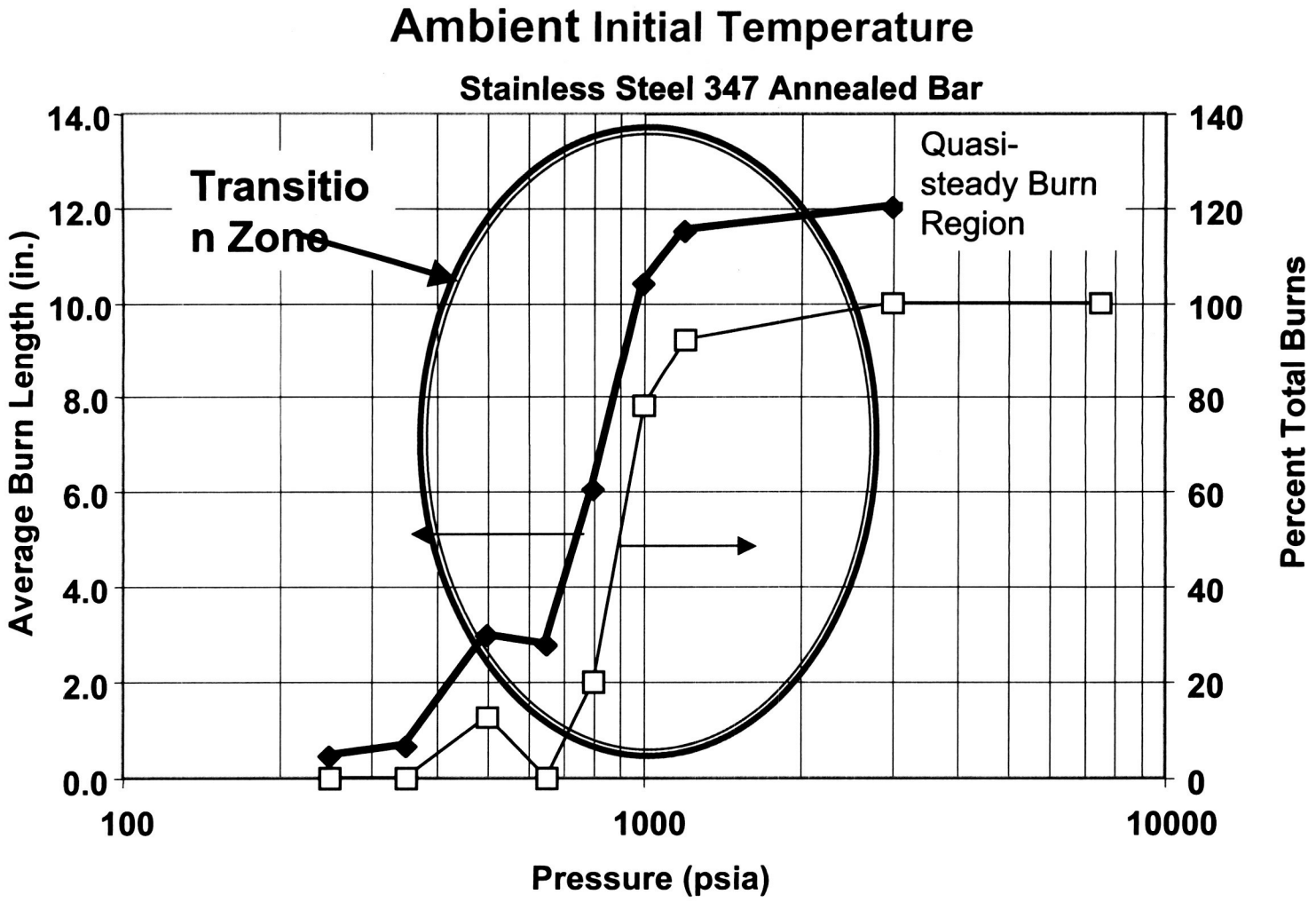
Outline

1. **Review standard test data at ambient average temperature**
2. **Review Heated promoted combustion data at elevated temperatures and pressures**
3. **Review Heated promoted combustion data burn rates at elevated temperatures and pressures**
4. **Examine the implications of this data and testing technique on future vehicle design**

Raw Promoted Combustion Burn Length Data (SS 347)



SS 347 Total Burn Percent



Similar Observations by Other Investigators

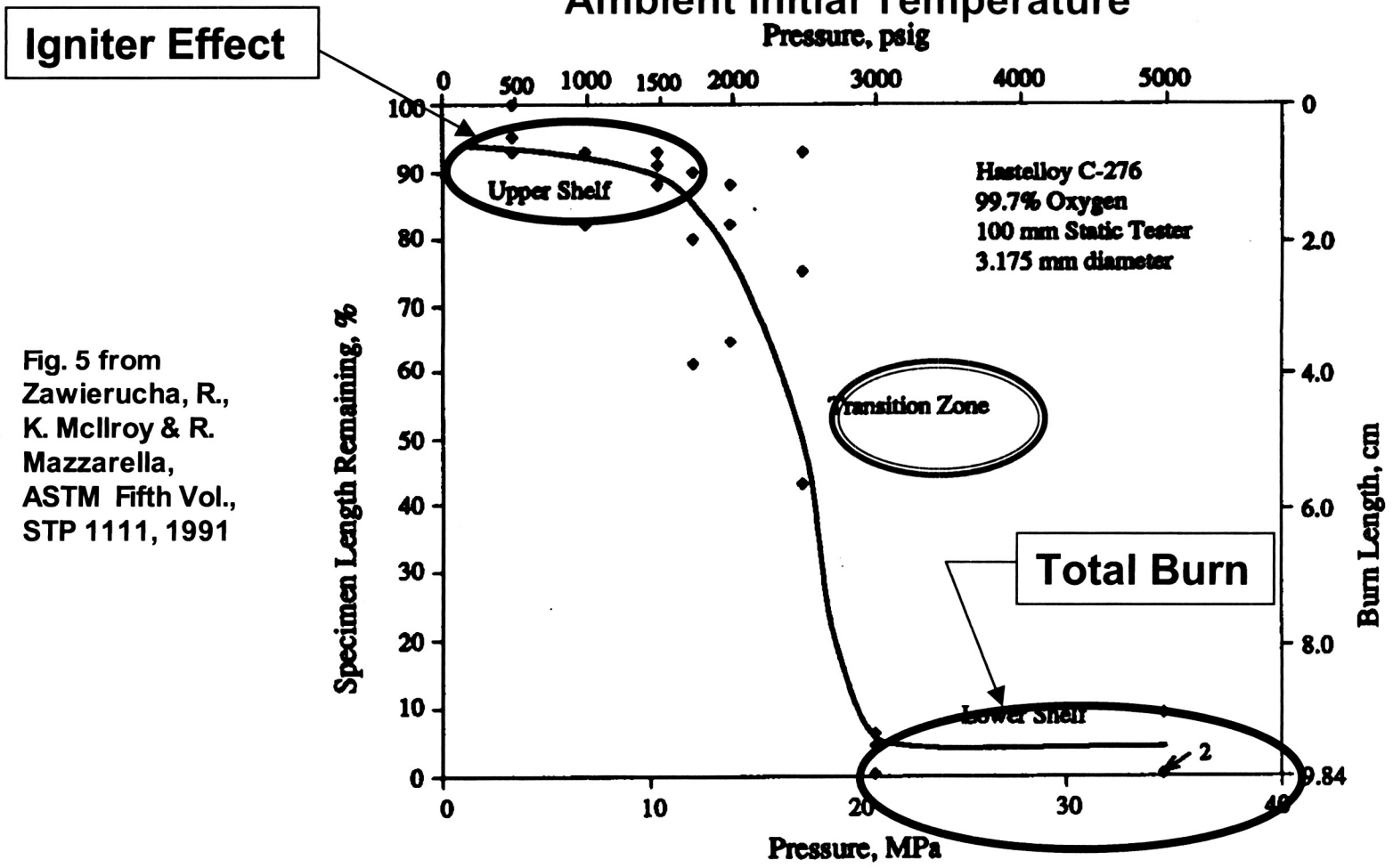
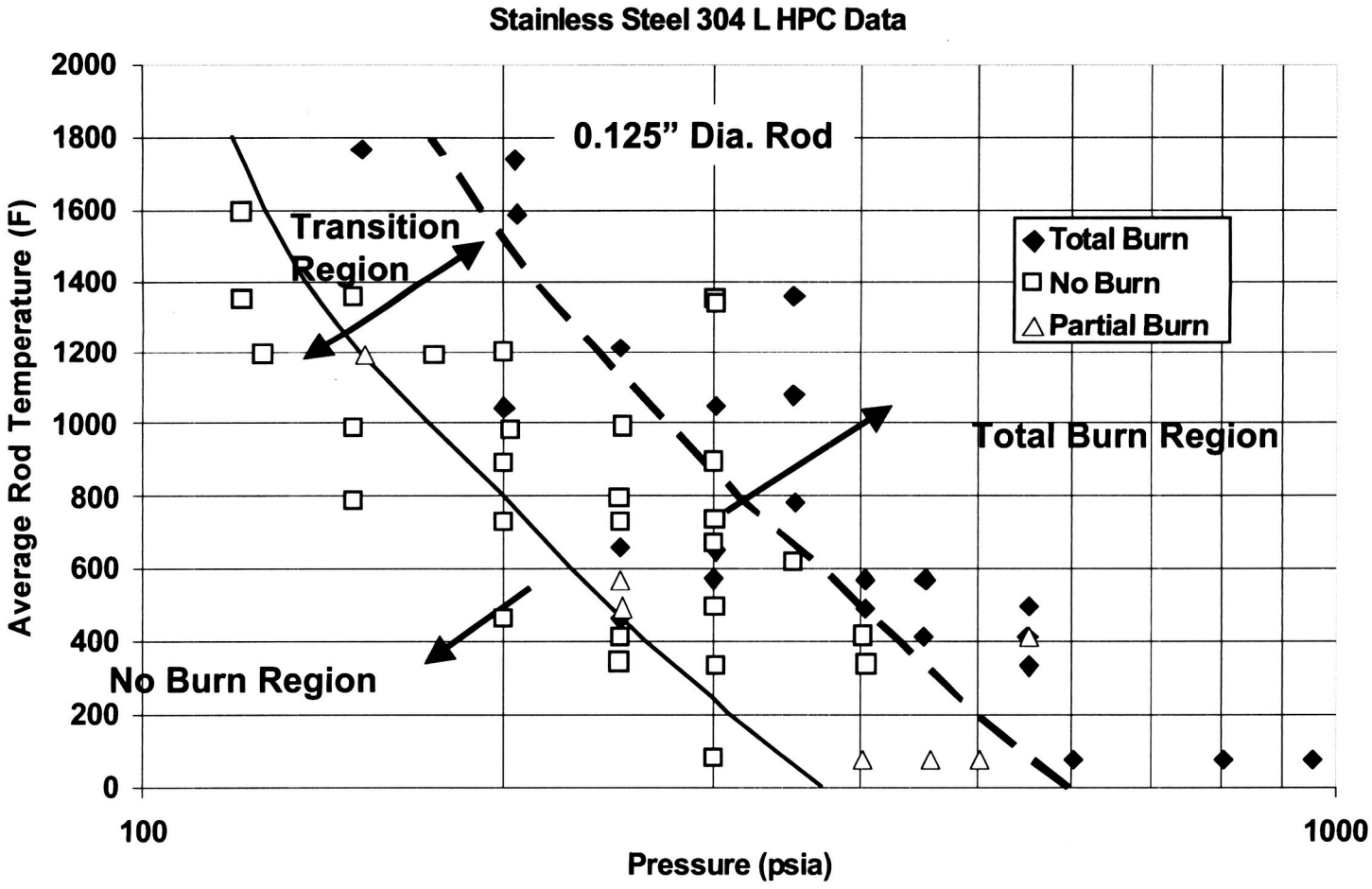
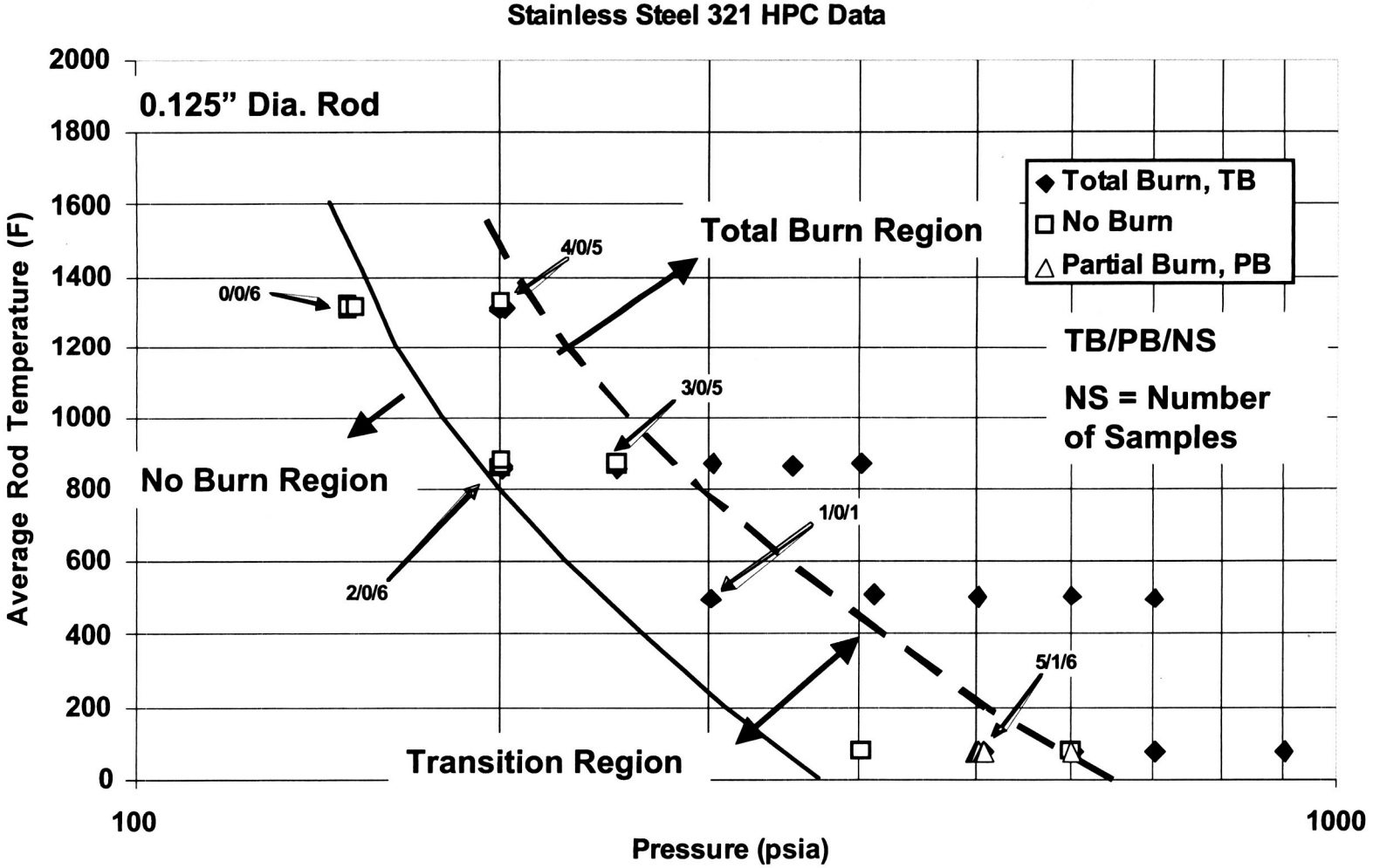


Fig. 5 from Zawierucha, R., K. McIlroy & R. Mazzarella, ASTM Fifth Vol., STP 1111, 1991

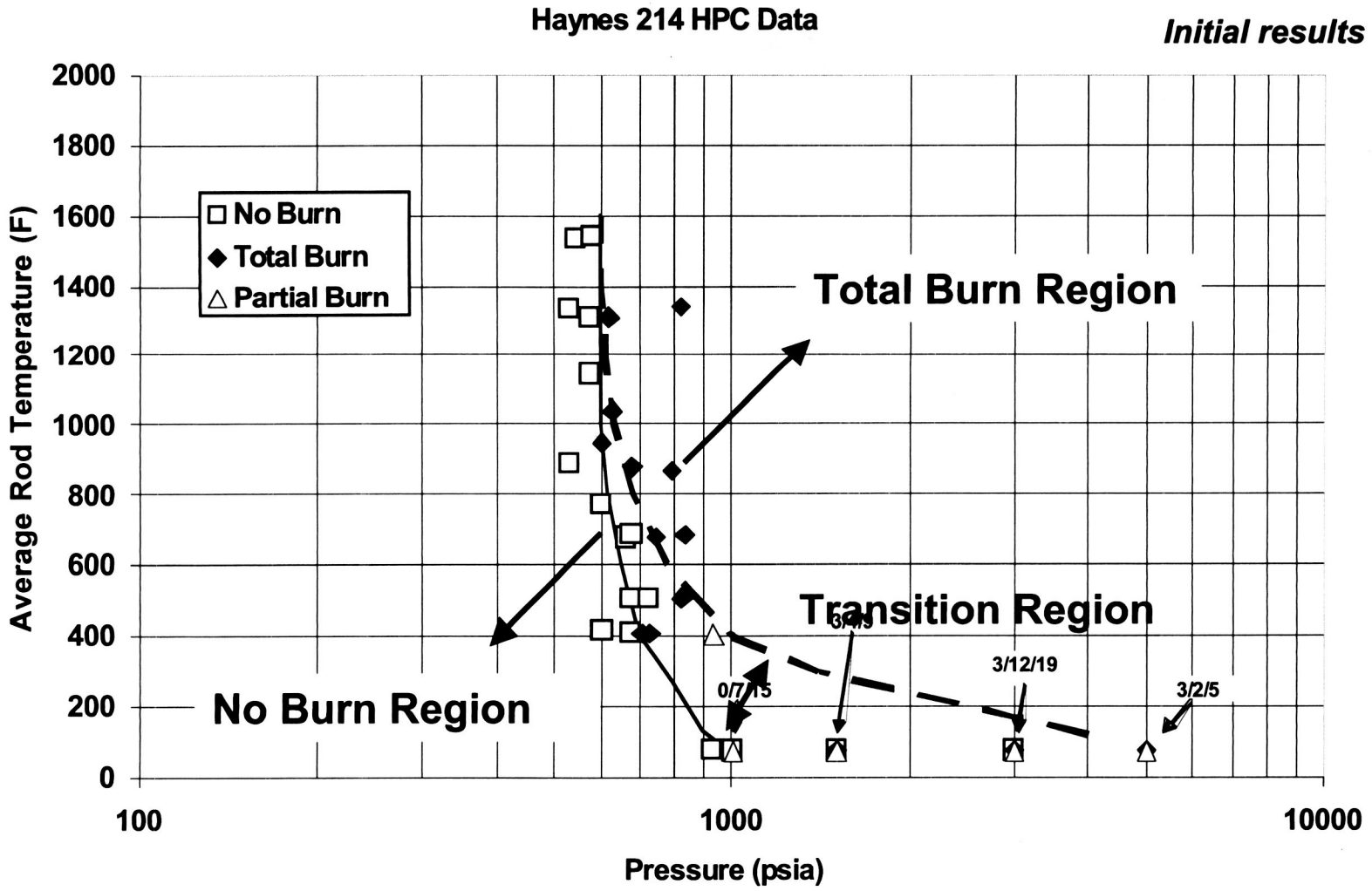
SS 304L Pressure –Temperature Burn Characteristics



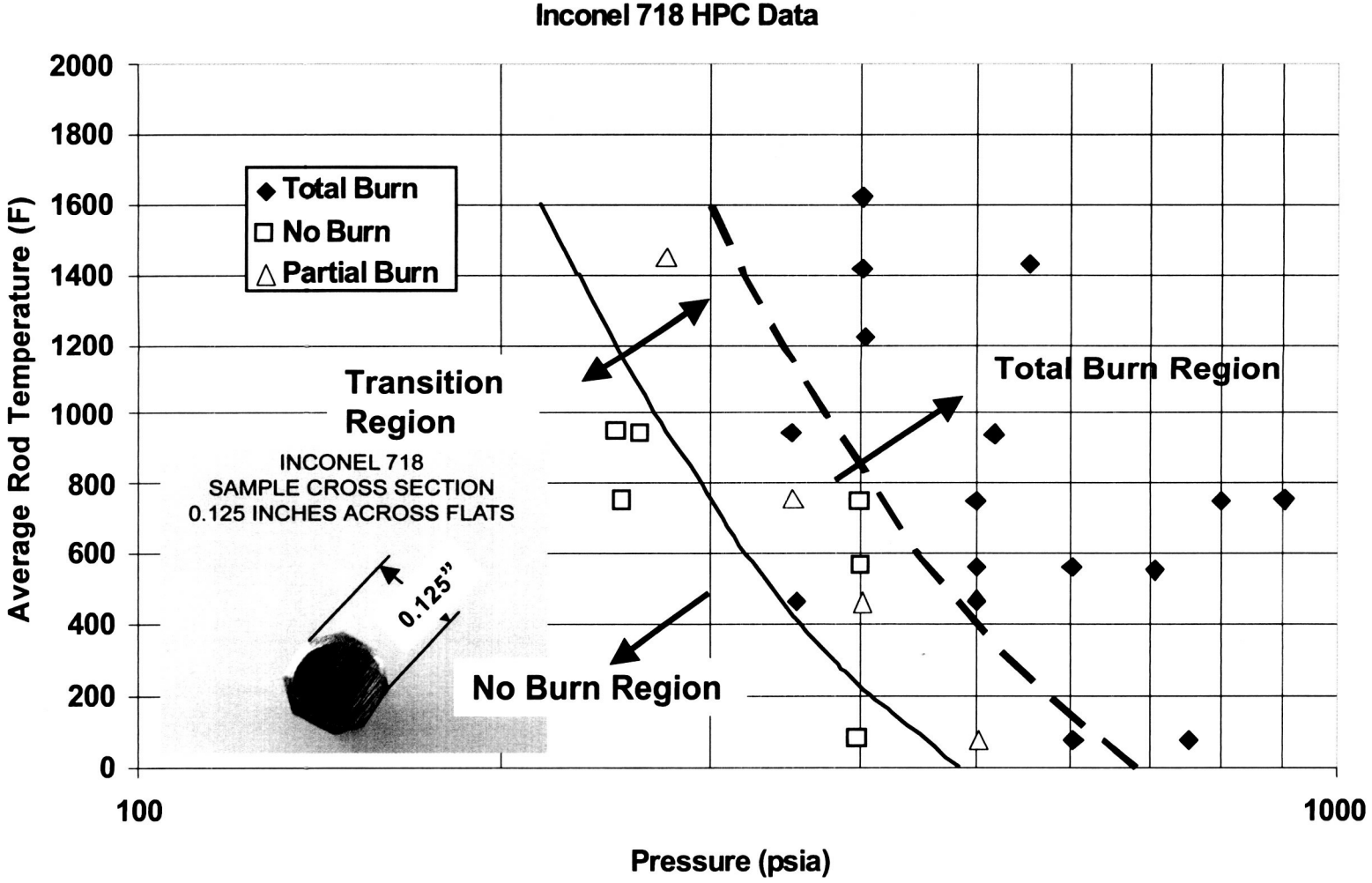
SS 321 Pressure - Temperature Burn Characteristics



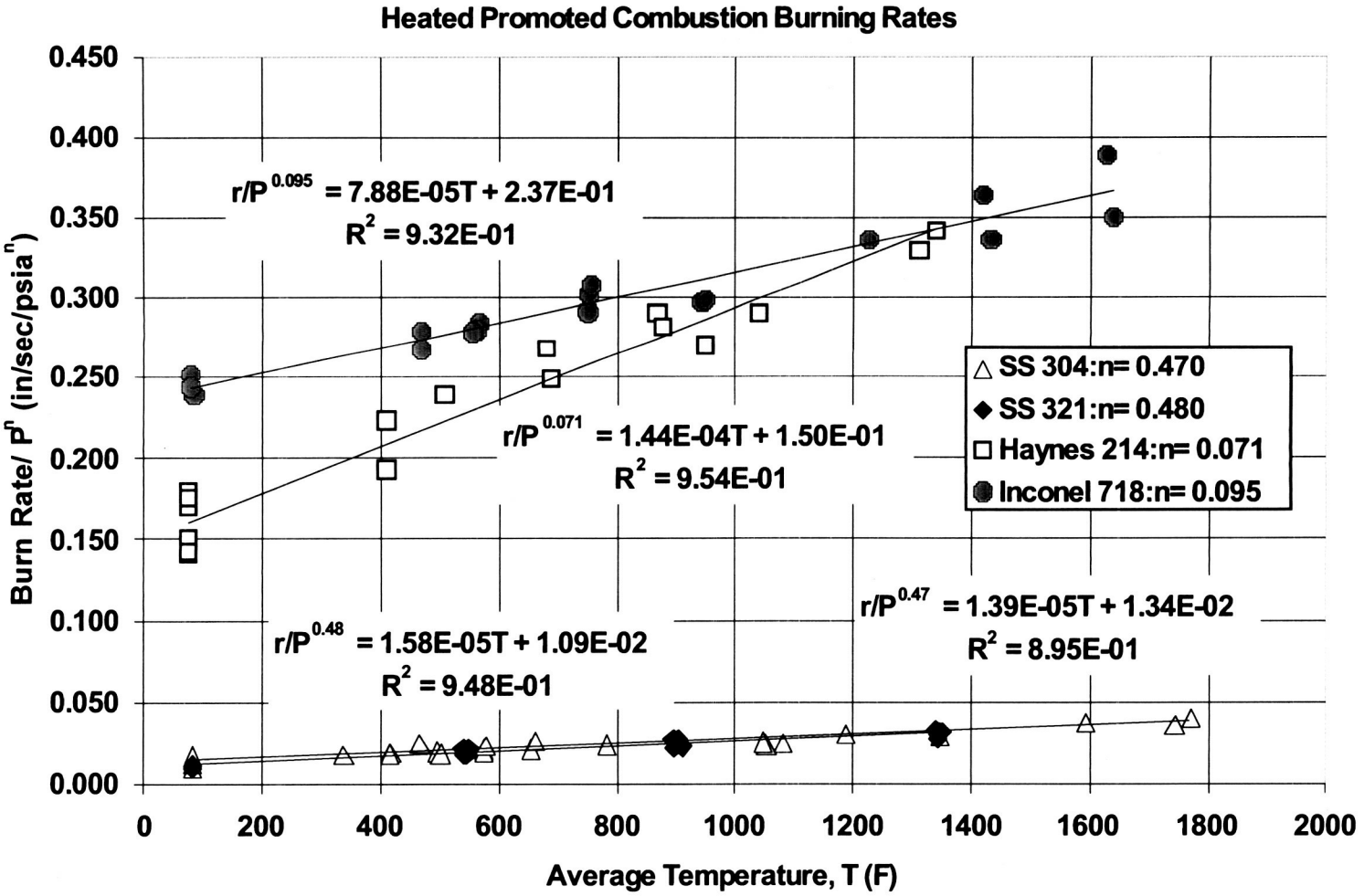
Haynes 214 Pressure –Temperature Burn Characteristics



Inconel 718 Pressure Temperature Burn Characteristics



Composite Burn Rates



Observations

- **Elevated average temperature significantly reduces the Ignition Pressure of the tested Metals**
- **Four tested metals: Stainless Steel 304L, Haynes 214, Inconel 718, and Stainless Steel 321 all exhibit a very significant reduction in the pressure where Ignition and total burning occurs compared to ambient initial temperature conditions.**
- **The total burn rate data appear to correlate quite well with an exponential power of pressure and a linear function of average temperature.**
- **The elevated average temperature effect has significant implications as to the oxygen compatibility of metals at high metal working temperatures.**

Implications

Testing

Material environmental condition ranges (P,T) must be defined and tested.

- **A much larger set of runs must be made to determine ignition risks.**
- **A different testing protocol must be established.**
- **Engineering math models must be established to extend tested sample data to application conditions**